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USING THE COMPUTER TO FOSTER CREATIVE INTERACTION AMONG STUDENTS

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ABSTRACT

The network characteristics of the PLATO computer-based education system permit students to communicate not just with the computer but with each other. This capability can be exploited in educationally significant ways. In addition to the social interaction which occurs when students help each other at the terminal, and when they work together at a terminal in two-student lessons, students can interact in "real time" from widely separated terminals, and they can see and learn from products generated by other students who were working not only at other places but at other times. This results in a variety of experience, a richness of expression, and a degree of motivation that is difficult or impossible to attain when a student works at a terminal in effective isolation from his peers.

THE COMPUTER SYSTEM

The PLATO computer-based teaching system (Lyman, 1978; Smith & Sherwood, 1976), developed at the Computer-based Education Research Laboratory (CERL) at the University of Illinois, consists of a large central computer connected to about 1000 terminals located in public schools, community colleges, universities, correctional institutions, military training schools, and other institutions throughout Illinois and other states. Each terminal consists of a screen on which the computer displays text and graphics to the student and a keyset which the student uses to interact with the computer. Most PLATO terminals also allow students to communicate with the computer by touching the screen. The system allows graphic displays, powerful answer-judging algorithms, and "instant" response to student input. Instructional materials are available in over 100 subject areas, ranging from lower elementary grades to university graduate course level (Dugdale & Vogel, 1978).

PLATO IN THE SCHOOLS

Since 1974, PLATO terminals have been a part of the learning resources in six to twelve intermediate grade classes in the Champaign and Urbana, Illinois, public schools, where the students use PLATO as a part of their mathematics work. A typical classroom is equipped with four PLATO terminals. The classroom teacher is responsible for scheduling the use of the terminals and for assigning PLATO topics so as to meet the specific needs of his students. On-line and hard copy data about students' progress and performance are available to the teacher. An overview of the use of PLATO in school mathematics is available in Dugdale and Kibbey (1977). For more information about the structure of the curriculum, see Dugdale and Vogel (1978). Results of a two-year external evaluation by Educational Testing Service of Princeton, New Jersey, indicated that these PLATO materials had a marked positive influence on students' achievement in mathematics and attitude toward math (Swinton, 1978).

INTERACTION AMONG STUDENTS

Terminals are grouped together in the classrooms in order to encourage interaction among the students. A student will often be proud of something he has done and will be eager to show it or explain it to a friend. Other times a student may turn to a classmate for help with a lesson. Generally, the materials are so motivating that the interaction among students at the terminals is centered around their work and does not take them "off task". A student who needs help is rarely willing to let another student take over and do the work. Usually the student will accept only the help he needs in order to become self-sufficient again.

Because tasks are generated for each student individually, the students also find that it is not helpful to copy an answer from a friend's screen. They can, however, learn ideas and strategies from watching a friend. For example, two students are working at adjacent terminals. PLATO displays some balloons tied to a number line.[1] The task is to tell where on the number line to shoot darts to burst the balloons. (See Figure 1.) When a student types a number, a dart flies across the screen and lodges in the number line at the point corresponding to the student's answer. One student, unsure of what to do, looks to see what his friend is doing. (On PLATO, as elsewhere, watching a game being played often helps one to understand the directions.) His friend has just shot a dart at 3/4 and hit a balloon. So the student turns back to his own terminal and types 3/4. But the dart does not hit a balloon, because there is no balloon at 3/4 on his number line. Clearly, copying his friend's answers does not help. So he turns to his friend's terminal again, but this time the interest is in learning how to locate numbers on the number line. After a few minutes of watching and a few more trial darts, he is able to progress through the lesson on his own.

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[1]The lessons that are discussed in this paper are part of a curriculum designed by Sharon Dugdale and David Kibbey (1975). Other lessons intended to promote interaction among students have also been developed at CERL (Weaver & Seiler, 1977).

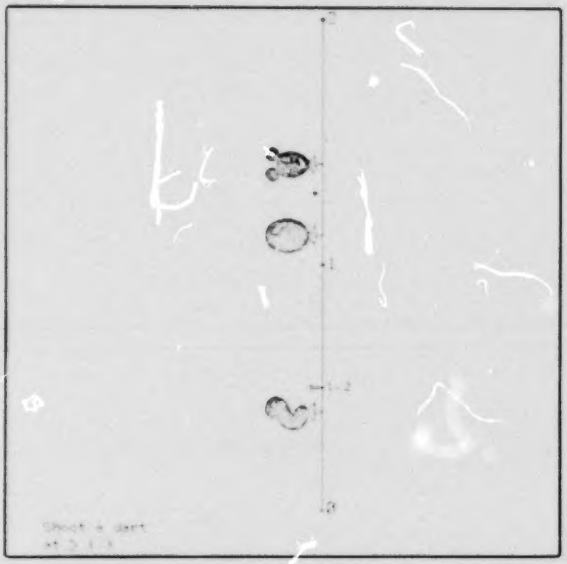

Figure 1. A display from lesson "Darts". Balloons are tied to the number line. The student shoots darts by saying where on the number line the dart should go. The dart flies across the screen and lodges in the number line, popping a balloon if it hits one. In this display the student has already shot a dart at 1/2 and has chosen to shoot the next dart at 1/3.

LESSONS THAT ENCOURAGE STUDENT INTERACTION

One-terminal Lessons

One kind of PLATO lesson designed to encourage interaction among students is that intended for use by more than one student at the same terminal. Such lessons are usually "games" for two players. Sometimes the students simply compete in an activity such as "Fractions Basketball" (Dugdale & Kibbey, 1977), where the players shoot baskets by writing appropriate fractions. Other lessons have students make up problems for each other, as in "High Wire" (Dugdale & Kibbey, 1977), in which one student "hides" a monkey on a number line by writing an addition of fractions problem, then the other student tries to locate the monkey by writing the correct sum.

Interterminal Lessons

A broader interaction and sharing of ideas is possible by exploiting the network characteristics of the PLATO system. One popular interterminal

lesson is "Torpedo", a game that provides practice in estimating distances on a number line. (See Figure 2.) One player controls a boat, and the other a submarine. The object is to move to a point above (or below) the opponent's piece and shoot it. Sea animals are obstacles that can be used to hide behind. The players take turns. On each turn a player can move his piece, or he can move-and-shoot.

Because each game lasts only a minute or two, the student can play with many different opponents in a short time. The opponent's move specifications are shown on the screen, so the student is likely to see a variety of methods, e.g., common fractions, decimals, or expressions with operations.

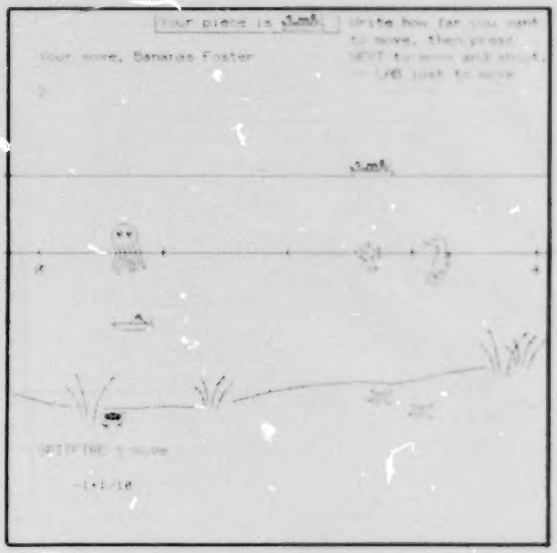

Figure 2. Display from lesson "Torpedo". The student has chosen to call himself "Bananas Foster". His object is to move his battleship to a position above his opponent's submarine and shoot the sub, avoiding the sea animals in between. To do this he must read and use the scale on the given number line. The opponent, "SPITFIRE", has just moved his submarine "-1+1/10" to hide under the octopus. (One might speculate that SPITFIRE's thinking could have been that a move of -1 would be a little too far to the left, so adding 1/10 would be about right.) Because each player sees the expressions his opponents write, students quickly learn a variety of useful ways to write such expressions.

A simple example of the resulting exchange of ideas is the students' use of zero. Typically, a student who is new to this lesson will not use zero. Even when he finds his game piece positioned ready to shoot the opponent's piece, the student will enter a small non-zero number rather than zero. Sometimes, much to the student's distress, the small non-zero move will not only miss the target, but will leave the student's piece where a more experienced opponent will shoot it with a move of zero. (See Figure 3.) It seldom takes more than one or two such experiences before the new player realizes that zero is a perfectly good number which measures a sometimes-useful distance.

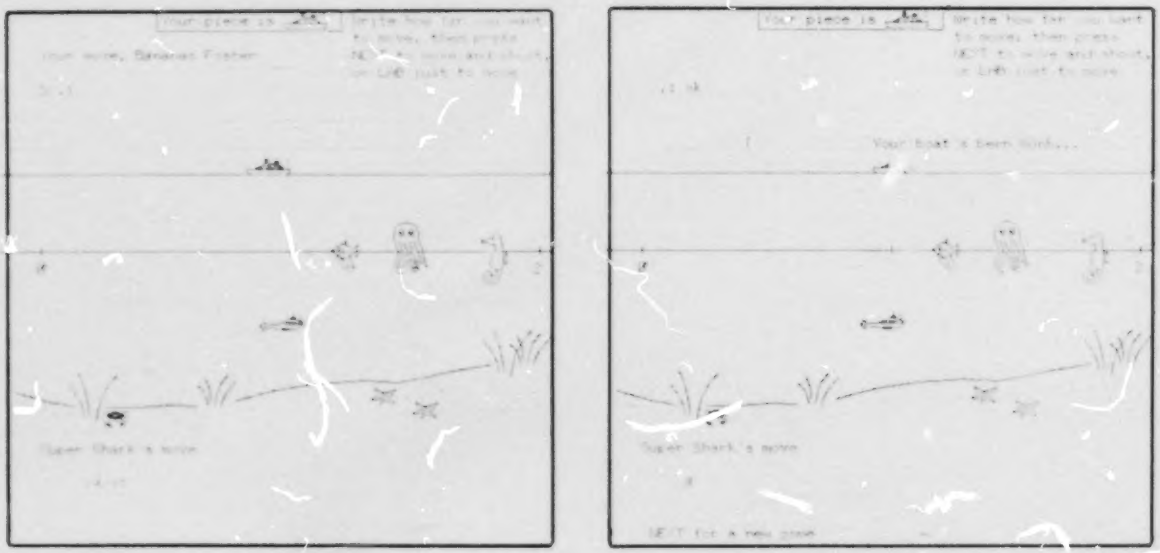

Figure 3. Two frames from "Torpedo". In the first frame the student, "Bananas Foster", is positioned so that a move of zero would win the game, but he has instead chosen to move .1, hoping that it will be a small enough move to still hit the opponent's piece. It is typical for students not to think of using zero until they see other students use it. As the second frame shows, .1 was not only too big a move (the weapon is on the front of the ship), it left the battleship directly over the sub's weapon. "Super Shark", a more experienced player, has ended the game with a move of zero. "Bananas Foster" will probably use zero next time the chance arises, rather than taking a chance on moving too far with a non-zero number.

"Torpedo" allows students to interact with many different people, but each short game involves only two students. Another interterminal lesson, "Obstacle Course", allows as many as four students to participate together at a time. (See Figure 4.)[2]

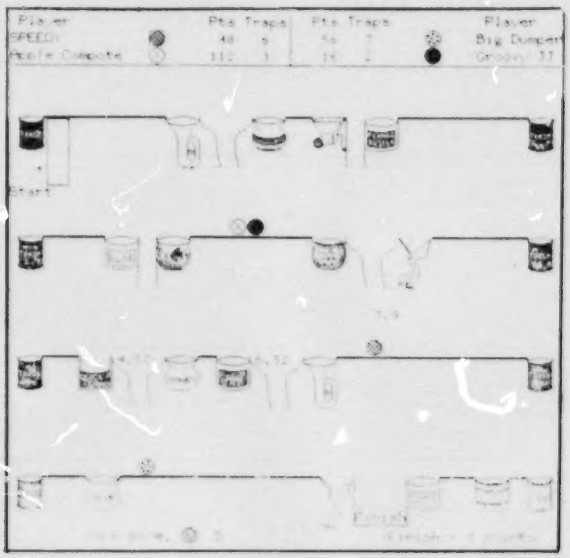

Figure 4. Display from lesson "Obstacle Course", which provides practice in quickly estimating differences between decimal numbers. Four students, playing from separate terminals, have chosen to call themselves "SPEEDY", "Apple Compote", "Big Dumper", and "Groovy JJ". Each player has a ball on the obstacle course. The object is to move one's ball through the course via the chutes without falling into any traps. Points are earned by reaching "FINISH". This is the display on SPEEDY's terminal. SPEEDY's ball is at point 7.9 on the third line. SPEEDY has to write a number to move his ball to a chute through to the next line. These wide chutes are easier to hit with a quick estimate. The narrow ones (see lines one and two) require more accuracy. Players do not wait to take turns. Each makes successive moves as quickly as he can.

A feature of both "Torpedo" and "Obstacle Course" is that students make up pseudonyms for themselves. (See Figure 5.) Students are free to use their real names, but they almost never do. Besides being considered fun, this anonymity avoids embarrassment over mistakes and encourages participation of the students most in need of the practice.

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[2]The several number line activities described here may appear at first glance to be undesirably similar to each other. A reader with this perception should look more carefully. Each activity has a different objective and makes different demands on the student.

Figure 5. Choosing an opponent for a game of "Torpedo". The pseudonyms of all players are listed. Players may be geographically widely scattered. The student may choose an available opponent, choose to play against PLATO, or wait for someone to challenge him.

Library Lessons

Another type of lesson that uses the network capabilities of the PLATO system is the "library" lesson.[3] In a library lesson a student does some mathematically relevant creative work and is then given the option of saving his work in a "library" so that other students can see it. He may replace his work with something new at any time. Each class has a separate library. Students are able to see the work stored in other classes' libraries, as well as their own. This provides an ongoing exchange of ideas among students in many different classrooms, even in different schools and communities.

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[3]The idea of library lessons was originated by David Kibbey. The work was begun in 1973 and first reported by Robert B. Davis, then Director of the PLATO Mathematics Project, at the NATO Advanced Study Institute on Machine Representations of Knowledge Conference, University of California, Santa Cruz, California, July, 1975. The resulting paper was published in Machine Representations of Knowledge (Davis, Dugdale, Kibbey, & Weaver, 1977).

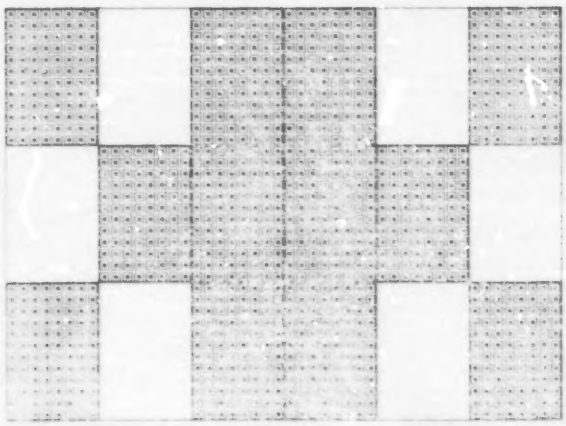
In the "Paintings Library" the student is asked to "paint" a particular fraction of a box. By touching the screen, he can draw lines on the box and paint areas of the box. When he has finished painting the correct fraction of the box, the student can choose to save his painting in the library. Figure 6 shows a few such student paintings.

Social interaction is quite apparent when fads spread through class libraries. For example, one student might paint a fraction of the box to show his initials. Within a few days, there will be many paintings showing other students' names and initials. Our experience has been that a large number of students participating in a library is a very important factor in its success. This lesson was first tried with only four students, and although they were described as bright, creative students from an open classroom environment, their paintings were quite unimaginative. Each student did some paintings and looked at the paintings done by the other three, but new ideas were few and enthusiasm was only mild. However, during a three-week period when 300 students used the lesson, it exploded with new ideas as students looked at each other's work and responded with their own.

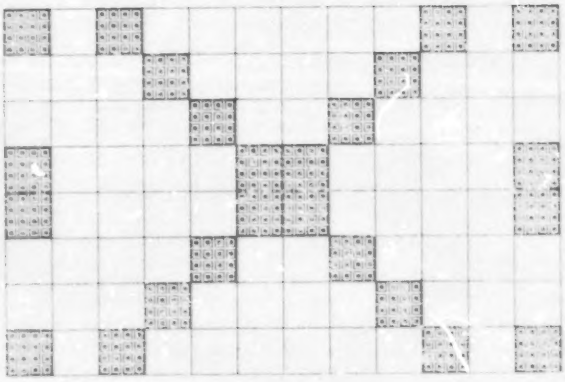
This lesson and others like it provide strong motivation for students to engage in tasks which require them to relate mathematical concepts to concrete models. Students are observed to engage in many lines of mathematical thought when creating a painting. For example, if the student has chosen 3/5 as the fraction to represent, and in doing a creative pattern has mistakenly painted 1/20 too much, PLATO will say, "You have painted 13/20 of the box". The student must then decide whether that is too much or too little and how much paint to add or remove. Some students will count same-size pieces and possibly use equivalent fractions. Others will visualize moving painted parts around to make an equivalent simpler painting. Still others may partition the box and deal with the parts separately, deciding whether 3/5 of each part is painted.

Later in the curriculum is the "Paint Addition Library". Here the student can use two kinds of paint to illustrate an addition problem. Students can ask PLATO for a problem to illustrate or make one of their own. In either case, when the student has correctly represented the problem, he must tell how much of the box is painted all together. This

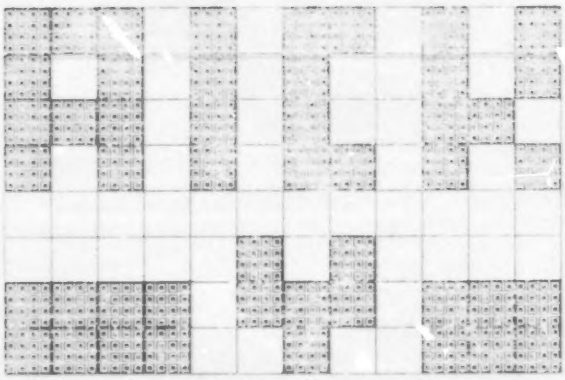
This is how mara painted 2/3 of the box.



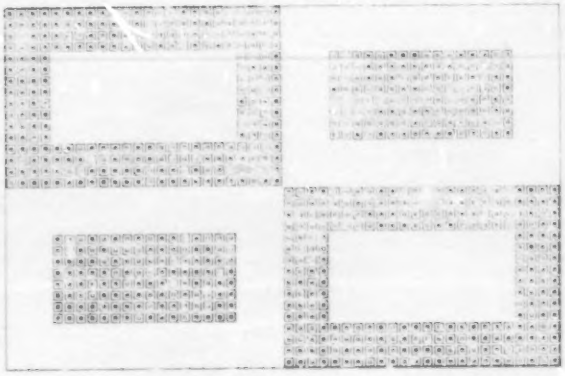
This is how johanna painted 1/4 of the box.



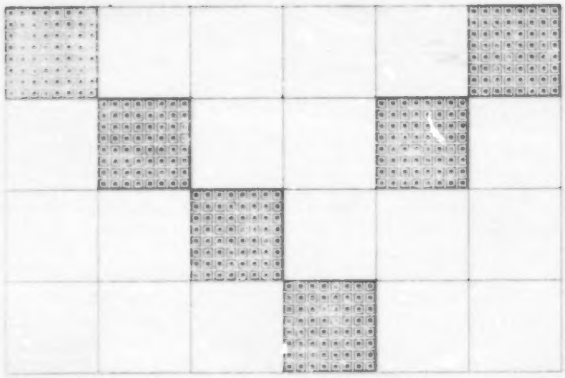
This is how ricky painted 1/2 of the box.



This is how brian painted 1/2 of the box.



This is how leah painted 1/4 of the box.



This is how jim painted 1/2 of the box.

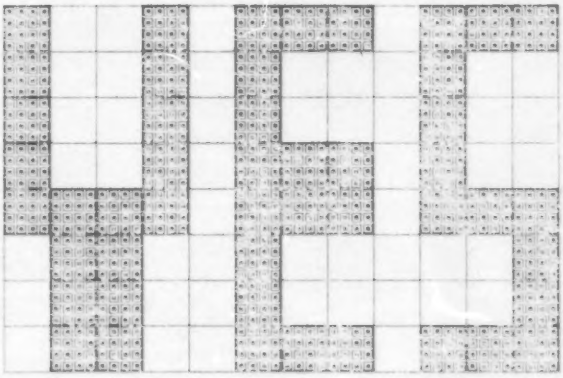


Figure 6. Some paintings that students have chosen to share through the library. The student's name and the fraction painted appear above each painting.

This is eric's painting: 1/4 + 1/3 + 7/12

This is lisa's painting: 4/32 + 16/32 + 28/32

This is benson's painting:

4/15 + 2/3 + 14/1

This is allison's painting: 40/64 + 24/64 + 1

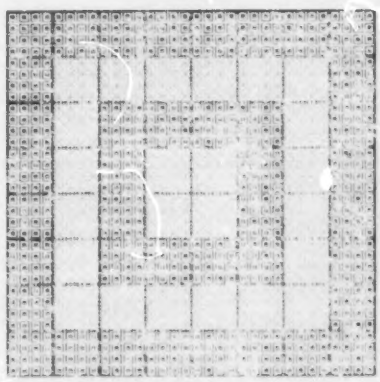


Figure 7. Four students' contributions to the "Paint Addition Library".

may be done by several methods, including drawing lines on the box until it is divided into some number of equal pieces, each of which is either all painted or all unpainted. (This is a visual method of finding a common denominator for the two fractions.) Figure 7 shows four students' representations of various additions.

"Skywriting and Spider Web" is a library lesson that lets the student write a "program" to move an airplane or a spider around the screen. (See Figure 8.) The airplane leaves a trail of smoke, and the spider leaves a web, so that the student's program makes a pattern on the screen. The simple programming language has three commands:

"f" to go forward (specify how many units)

"t" to turn (specify what fraction of a turn)

"r" to repeat the program

There is also an option to turn the smoke or web off and on.

Figure 8. Writing a program in the "Skywriting and Spider Web" library. The airplane has been instructed to go seven units forward, then turn 2/3 of a full circle. The program is recorded at the top of the screen as it is written. The key to the simple programming language is shown at the bottom of the screen.

Figure 9. A few students' programs from the "Skywriting and Spider Web" library.

When the student has finished writing a program, he has the option of giving the resulting picture a title and saving it in the library. Figure 9 shows some programs from the library. In each frame the student's program appears at the top of the screen. At the bottom of the screen is the student's name and the title he has chosen for the picture. Each student has his own special space in the library to save a program. He may replace his program with a new one whenever he chooses.

This lesson gives the student experience with a simple programming language, with iteration, and with the idea of a correspondence between symbols and pictures. In addition, it applies fractions to the "turn", a fraction model very different from the common ones such as regions and discrete sets. There is also a great wealth of geometric content that can be pursued. For example, the spider's turns are spot rotations, while the airplane's turns are arcs of circles. One interesting exercise is to explore the difference this makes by running the same program with the spider, then with the airplane. Another possibility is to explore various "classes" of programs; e.g., programs of the form "n forward, 1/m turn, repeat" always make a regular polygon with m sides of length n.

CONCLUSION

The network characteristics of the PLATO computer system allow students to communicate not only with the computer, but with each other, This can have large educational payoffs. Students generate and share a wide variety of approaches to what is traditionally very stereotyped subject matter. The richness of the exchange is enhanced by the fact that the sharing takes place not merely across students, but across classes, schools, and even communities. Far from being a mere drill-and-practice robot, the computer can be a medium for social interaction, mathematical discovery, and aesthetic expression.

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